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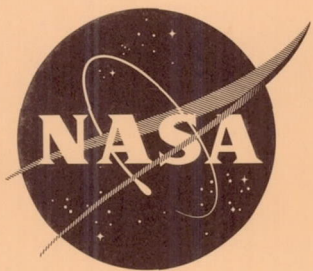
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# TECHNICAL NOTE

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DEVELOPMENT OF INFLATABLE COMPONENTS  
OF PERSONAL EQUIPMENT FOR ASTRONAUT BODY INSTRUMENTATION  
AND SURVIVAL AT SEA

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON

January 1963

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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DEVELOPMENT OF INFLATABLE COMPONENTS OF PERSONAL EQUIPMENT

FOR ASTRONAUT BODY INSTRUMENTATION AND SURVIVAL AT SEA

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SUMMARY

Five items of an inflatable nature were designed, developed, and fabricated. The items developed were a blood-pressure cuff, lifevest, liferaft, water container, and a radar reflector. Each item is discussed fully in this paper. Also discussed in this paper are the procedures used for the fabrication of these items.

INTRODUCTION

The possibility of an emergency egress following a landing on water or land necessitated the inclusion of survival equipment within the Project Mercury spacecraft. Prime emphasis has been placed on a water landing. Originally, standard aircraft survival equipments were provided for flight use. New requirements dictated by flight experience and the necessity to reduce weight and packed dimensions, and to improve component performance have resulted in the need for the development of the improved survival equipment discussed below:

(1) A pneumatic blood-pressure cuff was developed; and when it was determined acceptable, the cuff was approved for general flight use. Previously submitted cuffs were not acceptable.

(2) A carbon dioxide actuated liferaft, which is lighter, more compact, easier to manufacture, and more stable than the previously used raft, was successfully tested and approved. The liferaft was then incorporated into the survival kit for operational use.

(3) An internally actuated carbon dioxide lifevest was successfully tested, approved, and incorporated into the pressure-suit assembly for flight use.



(4) A water container for in-flight drinking and subsequent sea or land survival was integrated with the packed liferaft in space that is normally not used. As a result, the assembly is lighter and considerably more efficient and versatile than the water systems previously employed. The container was successfully tested, approved, and incorporated into the survival kit for flight use.

(5) An inflatable corner radar reflector, which is lighter, more compact, and easier to erect than other reflectors available for the purpose, proved to be successful in preliminary tests but required further confirmatory testing by search and recovery personnel prior to incorporation into the survival kit for use in recovery operations.

## DISCUSSION

### Fabrication Technique

The general manner of fabrication of the inflatable items is presented in this section.

A design outline or pattern of the proposed item is generated from a three-dimensional conceptual drawing and projected upon a single plane. Based upon the flat pattern, greater width is added until the desired cylinder diameter is achieved; that is, assuming an equal ply or a two-layered construction for the cylinder, one ply width is equal to the following formula as desired:

$$\frac{\text{Cross-sectional diameter} \times \pi K}{2}$$

where K is a factor representing percentages of stretch modulus of the material. For example, if

5 in. = Desired cross-sectional diameter

0.9 = Empirically derived K

x = Desired pattern width

then

$$x = \frac{(5)(3.14)(0.9)}{2} = 7.065 \text{ in.}$$

In the event that long inflatables are required, such as those used in liferafts, where tube lengths are over 4 feet and tube diameters vary

from 9 inches to 15 inches, it becomes necessary to "bias" the fabric layups in order to preclude unusual distortions which occur with increases in internal pressure.

The normal procedure is to use fabric in which the left and right biases are built into the material by coating the obverse side of the supporting fabric for one length of material and coating the face side for an equal length of material. The fabrication of the end item then proceeds as follows:

The top ply of cylinder fabric is alternated to its associated under ply for either the right or left side of an equilateral inflatable item. The opposing left or right counterpart is similarly but oppositely alternated to its associated under ply. Then, all four fabrics are joined by a flat overlapped seam and taped externally. Figure 1 displays this system of biasing fabrics so that innate twisting caused by fabric bias is eliminated.

Another technique employed was the fabrication of all units on the "flat."

After the pattern has been evolved and the fabrics biased and joined, the pattern is outlined in soft pencil on one ply of the coated side of the material. The line on the fabric is then covered on either side with three separate coats of neoprene cement (ref. 1). A V-tape is then manufactured by folding conventional bias tape along its length and lightly cementing the fabric-side surfaces to each other with a cement with poor strip-peel characteristics, that is, natural rubber cement applied to nylon fabric.

When the outline of cement on the coated side of the fabric is tacky, the folded edge of the tape is applied to the line that shows from beneath three coats of the adhesive so that the open tape edges are not exposed. (See fig. 2.) The disposable backing is removed from the tape and the adhesive side of the tape itself is activated with toluol or benzene prior to application.

A solution of talc or zinc stearate is then prepared by mixing this powder with water until a thick, stiff cream-like consistency is obtained. This solution is then brushed over all areas encompassed by the tape (fig. 2) to insure the "deadening" of these portions so that when the cover is applied it will not adhere to the bottom ply except where it is desired.

By placing a layer of material that has had three coats of adhesive applied to it over the entire unit, a completely airtight assembly is obtained. The cover is applied easily and evenly as illustrated in figure 3.



The jig pictured is so constructed that the hinged area A is set on sliding holes through fixed screws. Thus, any variation in the thickness of the fabric is automatically compensated by a rise in the cover plate in relation to the under ply.

The next step is to remove the wooden jig cover from the cover fabric and to roll the two-ply laminate vigorously over the areas where the material is to be cemented together.

The unit is then trimmed to within about  $3/8$  inch from the folded edge and allowed to cure for 24 hours. An oral inflation manifold is then bonded in place and the unit is inflated slightly through the oral inflation tube. The oral inflation device can also be affixed to the inside of the top ply before it is joined to the bottom ply. The device is affixed by punching a hole in the fabric and applying the manifold to the material from the inside, threading the distal end in first, and cementing the proximal end to the inside surface (fig. 4). (A hole is cut in the wooden jig base to allow the fabric to lie flat and to prevent distortion by the oral inflation manifold assembly.)

After a 24-hour cure period, the bag pressure is increased slowly until the folded V-tape separates from its inner faces. The pressure is then reduced but the bag remains inflated enough to keep the surfaces from touching. The item is then allowed to cure an additional 48 hours. By the end of the total 72-hour period, the unit is ready for any tests that are to be conducted, not to exceed those suitable for the inherent strength of the base materials. In four of the five cases noted herein, the material conforms to the Military Specification shown in reference 2. The only case not covered by this specification is the bladder for the blood-pressure cuff, and it conforms with those specifications dealing with unsupported neoprene rubber molded or dipped products (ref. 3).

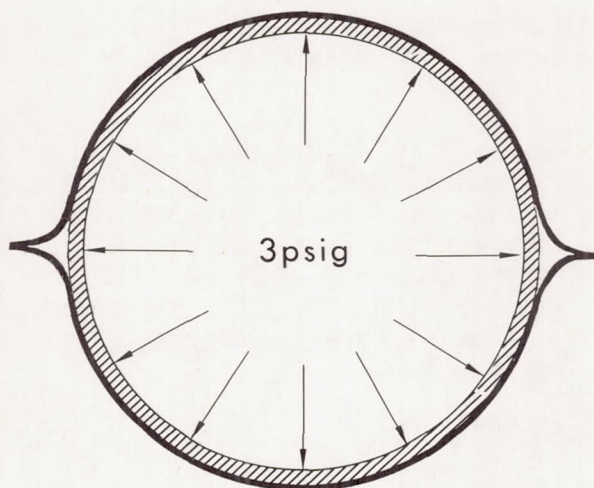
The following is a discussion of cold-cure cementing and joint procedures:

When two surfaces of rubber-coated fabrics are joined along a straight seam by the use of room-temperature setting adhesives (ref. 1), without benefit of reinforcements, the strength of the seam is a function of the peel or strip strength of the adhesive or, if this strength exceeds the coating adhesion to the fabric, the seam strength is determined by this latter characteristic. (See fig. 5.)

In general, the best prepared seams of constructions identical to the above rarely exceed 7 pounds of peel-strip strength per inch of width. Normally the method shown in reference 4 is used to make this determination. Coating adhesion tested by the peel method (ref. 2) does not require forces above 10-pounds-per-inch width to separate. Thus, an internal pressure of 3 psig in the item will cause a total

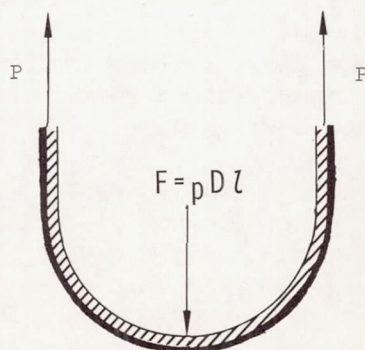


force on a seam of this type which will easily exceed these limitations, and the seam will fail.



Assume that a pressure of 3 psig produces tangential stress forces in walls of the cylinder. These forces will be the major cause of "peeling" of the bonded seams.

The following computations show that a pressure of 3 psig will cause the seams to fail:



therefore

$$F_Y = F - 2P = 0$$

$$2P = F = pDl$$

$$P = \frac{pDl}{2}$$



where

$P$  = Pressure (internal)

$D$  = Diameter

$l$  = Length

From

$$S = P/A$$

where

$S$  = Stress

$S_p$  = Peel strength

$$S_p = S = P/A$$

$$A = tl$$

$t$  = Thickness of material

Substituting

$$S_p = \frac{pDl}{2A} = \frac{pDl}{2tl}$$

$$S_p = \frac{pD}{2t}$$

For a hypothetical example, assume a maximum "peel" strength of 640 psi, a diameter of 9 inches, and a material thickness of 1/64 inch. The maximum internal pressure will be:

$$S_p = \frac{pD}{2t}$$

$$640 = \frac{p(9)}{2\left(\frac{1}{64}\right)}$$

$$20 = 9p$$

$$p = 2.22 \text{ psig}$$

Similarly, for a seam with V-tape having a maximum peel strength of 4,800 psi where seam breaks in shear the maximum internal pressure is:

$$S_p = \frac{pD}{2t}$$

$$4,800 = \frac{p(9)}{2\left(\frac{1}{64}\right)}$$

$$150 = 9p$$

$$p = 16.7 \text{ psig}$$

Thus, theoretically, an internal pressure of 16 psig can be reached with this type of construction. In actuality, this pressure very closely approximates rupture pressures performed on cylinders. However, the shear strength of a cemented interface will exceed 75-pounds-per-inch width of the seam, while the shear strength of a coating will invariably exceed even this force. The limitation of a pressure that can be applied internally to a coated-material inflatable item becomes a function of the breaking strength of the supporting fabric.

It becomes obvious that an extremely strong seam will result from a transfer of mechanical peel to mechanical shear along a seam, and that is exactly the seam construction developed (figs. 3 to 5) where the incorporation of the V-tape effectively transfers peel to shear.

#### Hardware Items

The five items of an inflatable nature that were designed and developed for inclusion in the Mercury spacecraft are discussed in this section.

Blood-pressure cuff.— The requirement of measuring an astronaut's blood pressure in flight created the need for an occluding cuff that could be worn continuously and that would be capable of extended application on a relatively active man. Minimum restriction to flight movements with minimal impairment to comfort and efficiency were of prime importance.

Several contractors had submitted cuffs of conventional design, fabricated in accordance with criteria established for the manufacture of clinical occluding cuffs. Although these items gave acceptable readings of diastole and systole, it was difficult for the subject to perform normal spacecraft work procedures. The cuffs were uncomfortable, and precluded normal elbow flexure when in either the inflated or uninflated state.



A smaller, softer, flexible, universal-size unit was fabricated by the NASA Manned Spacecraft Center and tested for accuracy and reproducibility of results against previously supplied cuffs of commercial manufacture.

The blood-pressure cuffs were objectively compared while being worn by the astronauts and on other flight personnel. Further tests of this nature were performed in the centrifuge at the U.S. Navy Aviation Medical Acceleration Laboratory at Johnsville, Pa. Subjective evaluations were performed by the astronauts. The results indicated that although the NASA cuff was significantly lighter and smaller than other cuffs, the quality of the data was equivalent to that obtained from the standard clinical cuff. Because the NASA cuff was more comfortable to wear, imposed relatively little impairment to normal movement, and remained in place without special provisions, it was preferred by all subjects tested.

Specifications and drawings were prepared, and flight units were procured. (See fig. 6.) Materials employed (ref. 5) are noted in figure 6 and methods of construction, patterns, and fittings are shown. Figure 7 is a photograph of the NASA blood-pressure cuff.

Lifevest.- As a result of the MR-4 recovery operation in which the astronaut had to make an emergency exit without his survival kit, it became apparent that an emergency flotation device was required to maintain flotation of a water-filled pressure suit. In order to reduce the hazards inherent in possible similar situations of this nature, the NASA Manned Spacecraft Center instituted the development of a miniaturized lifevest employing the following criteria:

- (1) Minimal bulk (less than 20 cu in.).
- (2) Minimal weight (less than 1 lb).
- (3) Minimal interference with flight efficiency.

On September 8, 1961, two basic configurations were fabricated: one consisting of a simple tube and the other a tube with inflatable hooks. (See figs. 8 to 10.) The inflatable hooks were constructed to provide a positive grasp to the wearer's shoulders, and incorporated easy don and doff features and adequate flotation characteristics without impairing rescue and recovery or impeding swimming capability.

Preliminary tests indicated the inadequacy of the simple tube (fig. 8). The lifevest with inflated hooks (fig. 9), however, warranted further development. (See fig. 10.)

On September 13, 1961, motion-picture coverage of pool tests confirmed the fact that the flotation characteristics of the vest and suit combination when the latter was filled with water, kept the wearer's



head well out of the water. When the vest was employed swimming was in no way impaired, whether the suit was waterlogged or not. Without the vest, the water-filled suit and subject sank immediately.

Internal carbon dioxide actuating devices were designed to reduce bulk and weight. (See figs. 11 and 12.) Several coated fabrics of a lighter weight were tested and one was selected. Three final prototype models were fabricated of this material which consists of 5-ounce nylon with 1.5-ounce neoprene coating (ref.2). In this form, the inflated hooks were given permanent curves by the insertion of internal V-shaped restraints. (See fig. 13.)

Packets were designed until the present configuration was accepted. The present configuration is trapezoidal, measuring 5 by 4 by 3 inches and 1 inch thick. (See fig. 14.) It weighs less than 1 pound (0.99 lb) and contains, in addition to the internal CO<sub>2</sub> charge of 16 grams, an oral inflator for topping. The packet is affixed to the suit below the neck ring and is directly attached to the vertical steel tiedown cords. A 6-foot lanyard is affixed to an eyelet in the vest and to the packet case to preclude accidental loss upon inflation. Placement of the package is optional. Present tests indicate the chest area to be just as satisfactory a location as the lower leg. The entire unit can be opened, inflated, and donned with one hand in less than 10 seconds by the test subject when he is attired in the pressure suit.

Tests were accomplished on October 10, 1961, in the open sea from a launch. The test subject first swam about with the pressure suit in the intact condition, its airtight integrity maintained. He then actuated the flotation device, donned it, and opened the zipper to his suit. The suit soon filled with water and the subject swam about unhindered. The subject was then instructed to remove the vest while he was tied to a safety line. He was unable to remain on the surface unless he was held there by the safety line or unless he grasped the over-the-side boarding ladder to the launch.

Final acceptance tests were performed at the environmental test facility at NASA, Langley Station, Hampton, Va. Test conditions, that is, high shock, acceleration, heat-cold, vacuum, and vibration were performed in accordance with figure 10 of reference 6. Additional tests were conducted in which the vest was inflated to 5 pounds per square inch for 5 minutes and then to 2 pounds per square inch for 2 hours. There was no evidence of leakage in either test.



The following table shows the inflated pressure of the lifevest caused by a 16 gram CO<sub>2</sub> cylinder at various air temperatures:

Air temperature, °F	Pressure, psi
40	2.08
50	2.12
60	2.16
70	2.21
80	2.25
90	2.29

Liferaft.— In November 1959, it was decided that the first liferaft to be tested for Project Mercury should be similar in design and material to the standard PK-2 raft with the following exceptions:

(1) Boarding of the raft was to be facilitated by the incorporation of a deflatable aft section that could subsequently be inflated orally by the occupant.

(2) Stability was to be increased through the incorporation of one bow ballast chamber located under the floor of the raft with a water capacity of  $1\frac{1}{2}$  gallons, and two smaller chambers placed right and left of amidships under the floor of the raft with a water capacity of 1 gallon each.

In January 1960, a raft of this description was tested in a pool at Langley Station, Hampton, Va. A subject (attired in a Mercury pressure suit) found the raft difficult to capsize and easy to board.

On March 28, 1960, an identical raft was tested in the open sea and in the surf. At this time it also demonstrated great stability, was easy to board and was generally superior to the conventional PK-2 with which it was compared.

After a configuration was selected, an attempt was made to reduce the weight of the raft by employing a lighter base fabric and coating. At the same time, it was thought possible to incorporate radar recognition into the raft by using a lightweight nylon mylar laminate with a coating of vacuum deposited aluminum. Langley Research Center fabricated three such rafts. Although a weight reduction of 50 percent was realized, subsequent tests have indicated little or no radar reflectivity advantage and very rapid degradation of the impermeability of the raft



(to a point where the only raft available could not be made to hold air). As a result, other rafts that conform to the NASA configuration were constructed of a durable, lightweight, radar-reflecting fabric.

In a further search of a way to reduce the weight of the raft assembly, stainless steel CO<sub>2</sub> cylinders were purchased. These cylinders have passed all tests (overpressure, vibration, and temperature) and appear to be satisfactory. A weight saving of approximately 8 ounces has been obtained over the conventional steel cylinder.

On October 10 and 11, 1961, sea tests were again conducted by cognizant NASA personnel using liferafts fabricated of conventional fabric, but constructed in accordance with the NASA configuration. These tests were performed by a subject attired in a Mercury pressure suit who inflated the raft in the sea, boarded it, inflated the aft end, and then demonstrated the innate stability characteristics of the assembly by standing up in the raft. He then sat on one side tube of the raft without capizing it.

On October 26, 1961, the first model (X-1) liferaft of radical departure from conventional liferaft constructions and materials was tested. Results indicated satisfactory or superior performance when compared with the results of tests conducted on conventional rafts or rafts developed to date for NASA. The unit is significantly lighter, packages to about one-quarter the thickness of conventional rafts, and offers over 3 square feet of additional space for the occupant. (See fig. 15.) This raft contains only 1 seam as opposed to 11 seams in the previous rafts. Further, it was fabricated "on the flat" which allowed for simplified and inexpensive fabricating methods and at the same time permitted compact packaging.

Two additional rafts were fabricated without boarding ramps; one with stabilizing buckets, the other without such devices. Preliminary tests indicated the possible redundancy of the boarding device and the stabilizers. When the raft was empty, the floor was held above the water; but when the occupant entered the raft, he forced the floor down and lowered the center of gravity at the same time. As a result, the pressure beneath the raft was reduced when the trapped air was forced out and apparently a partial vacuum was created beneath the floor of the raft. This partial vacuum sealed the peripheral tube to the water, as a suction cup to glass. The innate stability was good; but although preliminary tests indicated the possible redundancy of the boarding device and the stabilizing buckets, the partial vacuum, though adequate, could be broken when rough seas were encountered. The addition of the buckets provided a very stable craft.



The slight increase in tube volume required an increase of 0.04 pound of CO<sub>2</sub>, bringing the total weight to 0.53 pound required to inflate the raft to 2 psig.

Boarding aid handles were installed on the floor of the raft to facilitate entrance. The handles previously installed parallel to the length of the raft on the outer tube periphery were turned vertically for additional ease of boarding. Installation of the vertical boarding handles along with stabilizing buckets eliminated the need for boarding ramps.

Two more rafts were fabricated and strength tested to a pressure of 5 psig and shape retention after 24 hours with a pressure of 2 psig,

These rafts were then packed and subjected to the shock, acceleration, temperature, vibration, vacuum, and oxygen conditions as stated in reference 6. After passing these tests, the rafts were reinflated, repacked, and considered flight items for the MA-6 mission. (See fig. 16.)

Water container.- With the development of the fabricating methods described previously, it became easier to provide inflatable equipment in a prototype and final form basis than had been possible up to that time. The original spacecraft water containers were two inflexible plastic cases weighing 1 pound each with a water capacity of 3 pounds each.

By fabricating these items of coated neoprene on nylon fabric, an immediate saving of  $1\frac{3}{4}$  pounds is realized. In addition, a saving of over 220 cubic inches in volume is realized, inasmuch as the fabric bag, when filled with 6 pounds of water, takes up space equal only to the space already unusable in the liferaft kit.

The bags have been fabricated in accordance with the methods described before. Internal air pressures of up to 10 psig, uncontained, can be maintained; but contained within the kit, water pressures in excess of 10 psig will be required for filling.

Figure 17 shows the water container in the uninflated, unfilled condition. Water is forced under pressure into the container by means of the one-way pressure valve shown in the lower, middle, left-hand section. Water is obtained through the plastic spiral tube.

Figure 18 shows how the water container is packed into the survival kit. The liferaft is placed on top of the water container. Figure 19 is a close-up view of the drinking tube extending from the kit.



Filler assembly adapters are used to fill the bag with water. The volume of water desired is determined by overfilling the bag and venting the water until the desired weight is achieved.

The bag can be autoclaved in wet heat to achieve the necessary sanitation and sterilization necessary for maintenance of drinking water. In addition, a polyvinyl or estane liner in the bag insures tasteless water. A faint sulphurous taste is discernible without this precaution. Bags have been tested in accordance with the environmental tests described for other inflatables. Having passed these tests, the bags have been incorporated in the MA-6 spacecraft.

Radar reflector.- Planned landing areas (areas where a spacecraft can reasonably be expected to land) are occupied by ships and aircraft during missions. In all other areas containing the ground track, air rescue service aircraft are ready for quick takeoff and search.

If a landing occurs in a planned landing area, it is probable that the spacecraft will not be damaged; it should be quickly found and the astronaut removed if recovery aids are working. The longest access time is 12 hours.

If a landing occurs in a contingency area, it is liable to be of a catastrophic nature, necessitating quick exit by the astronaut, perhaps even before water or land impact. It is probably in these areas that a radar reflector would be most valuable.

The U.S. Navy and U.S. Air Force search aircraft are equipped with S- and X-band radars. Ships of the destroyer type usually associated with search operations are equipped with L-band radars. It is interesting to note that merchant vessels are also equipped with L-band radars.

On October 26, 1961, a series of radar-reflective tests were planned for the recently developed inflatable corner reflector.

These tests were proposed to determine the adequacy of an inflatable corner reflector as far as airborne search radar pickup was concerned in the open sea. Also the tests were to confirm previous tests with GCA radar performed on runway perimeters to determine the effectiveness of the corner reflector and the mylar liferaft previously reported to be undistinguishable from a water background on a radar screen. The GCA tests indicated that the corner reflector, when held aloft, and the raft, reflected a significant signal within the confines of the scope of the transmitted beam. Neither configuration showed up when placed on the ground.

The original water tests were not completed, since the radar plane arrived only after the NASA sea trials were finished. However, the



corner reflector was put over the side of the launch that was being used to transport testing personnel to the site of the sea trials and the reflector was allowed to float 200 feet from the parent ship. The radar operator of the Tactical Air Command reported that the corner reflector was picked up on the scope 5 miles away from an altitude of 2,000 feet. It was clearly distinguishable from the launch.

A second series of water tests have now been completed. Although the corner reflector is of very lightweight construction, is packaged in a volume of 8 by 2 by 1/2 inch and was orally inflated to a diameter of 39.37 inches, it was sited floating in the water by a radar-equipped aircraft. It was found that in sea trials it was feasible to raise this device up to 10 feet on a pole with little or no difficulty by a subject lying in a mylar liferaft fabricated by the methods discussed in the paper. It was theorized that this reflector would have been picked up at distances over 25 miles away, and should have been clearly discernible to the radar observer when it was elevated. This, however, did not prove to be the case; additional range was not immediately noted with this increase in height.

On January 3, 1961, a series of tests were performed employing a Robin reflector and the NASA developed inflatable corner reflector. The results of these tests, as complete as possible, are included in the appendix.

Generally speaking, the Robin reflector can be detected on the surface of the water up to 48 miles away under certain conditions. The NASA reflector has a range of 35 to 45 miles. However, the Robin reflector requires 18 cubic feet of air for inflation, while the NASA configuration requires about 1/2 cubic foot. The practicability of the first one is doubted. The range of the second, less than that of the first, may be improved. However, it should be noted that it requires only three breaths to inflate the latter unit.

Manned Spacecraft Center,  
National Aeronautics and Space Administration,  
Houston, Texas, July 30, 1962.

## APPENDIX

RADAR RANGING TESTS ON PK-2 LIFERAFT  
AND INFLATABLE CORNER REFLECTORS

By Charles W. Mathews

## SUMMARY

On January 3 and 4, 1962, radar ranging runs were made on a PK-2 rubber liferaft with aluminized mylar reflective splash cover and three types of inflatable corner reflectors located at various heights. Runs were made in the lower Chesapeake Bay area and in the Atlantic Ocean about 30 nautical miles off the Virginia Capes. Airborne radars used in these tests were standard APS-20 and APS-42 sets that are used by aircraft supporting Mercury recovery operations. The APS-20 is used in the WV-2 aircraft, and the APS-42 is used in the SC-54 aircraft. Radar ranges of 8 nautical miles were obtained by the APS-42 and ranges of 48 nautical miles were obtained by the APS-20. These tests were by no means conclusive, but the results indicate that inflatable corner reflectors can add appreciably to the effective sweep width covered by a search aircraft during a low-altitude visual-type search.

## REFLECTORS

The following reflectors were tested:

- (1) The MSC Inflatable Reflector No. 1 (shown in fig. 20) has 3-inch diameter inflatable neoprene-nylon tubes and aluminum webbing. The overall length is 39 inches from tip to tip. The tubes are also covered with aluminum.
- (2) The MSC Inflatable Reflector No. 2 is identical to No. 1 except that the tubes are not covered with aluminum. (See fig. 21.)
- (3) The Robin Corner Reflector is a 39-inch diameter spherical mylar balloon with an aluminum-mylar reflector attached to the inside surface. This reflector folds into a small package, but the 18-cubic-foot balloon volume makes it impractical to inflate orally. The balloon is also relatively fragile.



These reflectors were suspended from heights of 2 to 10 feet by varying the height of the telescoping pole. A PK-2 liferaft with aluminized mylar splash cover and 150 pounds of ballast (fig. 22) was used as a platform.

#### AIRCRAFT AND RADAR

One WV-2 and one SC-54 aircraft were used in this evaluation. The WV-2 aircraft was equipped with APS-20, S-band, 2-megawatt power radars (also used in P2V aircraft).

The SC-54 aircraft was equipped with APS-42, X-band, 52-kilowatt power radars (APS-31 radar used in SA-16 aircraft is very similar).

#### SEA CONDITIONS

The winds over the Chesapeake Bay gradually increased over the 4-hour test period from 5 knots to 15 to 20 knots with a corresponding increase in whitecaps and wave height (3 to 4 foot maximum). The MSC contract boat was used to monitor the raft.

The winds over the Atlantic Ocean gradually decreased over the 4-hour test period from 15 to 5 knots. Waves ranged from 3 to 5 feet with few whitecaps. A U.S. Navy rescue and salvage ship (USS Preserver ARS-8) was used to monitor the raft.

#### RESULTS

Range results are presented in table I. The results of the tests in the Chesapeake Bay area were very indefinite due to the presence of many targets in the area. The SC-54 aircraft in particular had trouble identifying the raft since there is no search capability in the rear sector and the aircraft could not fly over the raft for identification and hold the target while increasing range. The tests in the bay did point up the obvious problems of trying to support a reflector at any significant height above the water. The telescoping steel tube shown in figure 22 was used and was severely bent during the 15- to 20-knot winds experienced in the bay. The maximum height attainable with an 11-foot pole was 6 feet.

No identification problems were encountered in the Atlantic Ocean area except that the WV-2 radar operator believed that in one test he

had sighted the raft at 35 nautical miles but thought it was the ship. Generally speaking, the target intensity was good and the operators thought that sea return would not prevent the aircraft from homing on the raft. Also, no significant differences were attributable to changes from high altitudes to low altitudes; in fact, the air rescue crew flying the SC-54 preferred the lower altitude for radar search.

The radar ranges obtained by the WV-2 (APS-20) compare favorably with UHF beacon ranges, but few of these aircraft are involved in Mercury recovery and those are in the planned landing areas. The ranges obtained with the lower powered SC-54 (APS-42) are much less but could extend the effective aircraft search width considerably if a contingency area search deteriorates into a low-level visual search.

#### RECOMMENDATIONS

(1) Work should be continued on inflatable or springloaded corner reflectors with the use of surface radars to compare relative returns on new reflectors with the Robin reflector.

(2) Additional tests should be made with airborne radars as promising reflectors are developed.

(3) Telescoping and inflatable poles should be abandoned unless experience with the refined reflectors indicates that considerable improvement is attained in increasing the height from 2 feet to 8 feet.



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Table I -- Range Results

Location	Reflector	Height above water, ft	Maximum radar range, nautical miles		
			WV-2	SC-54	Ship
Chesapeake Bay	Robin reflector	2.5	(Alt = 2,000 ft) 8 to 13	(Alt = 1,000 ft) 6	
	{ MSC inflatable reflector No. 2	2.5	4 to 8	4	
		6.0	10 to 11	3	
Atlantic Ocean	Robin reflector	2.0	(Alt = 12,000 ft) 48	(Alt = 8,000 ft) 7 to 8	2
	{ MSC inflatable reflector No. 2	2.0	a 15	2 to 3	1
Atlantic Ocean	Robin reflector	2.0	(Alt = 1,000 ft)	(Alt = 500 ft)	2
	{ MSC inflatable reflector No. 1	10.0	45	9	
		1.5	19	8 7 } 2 to 3	

<sup>a</sup> Radar operator.



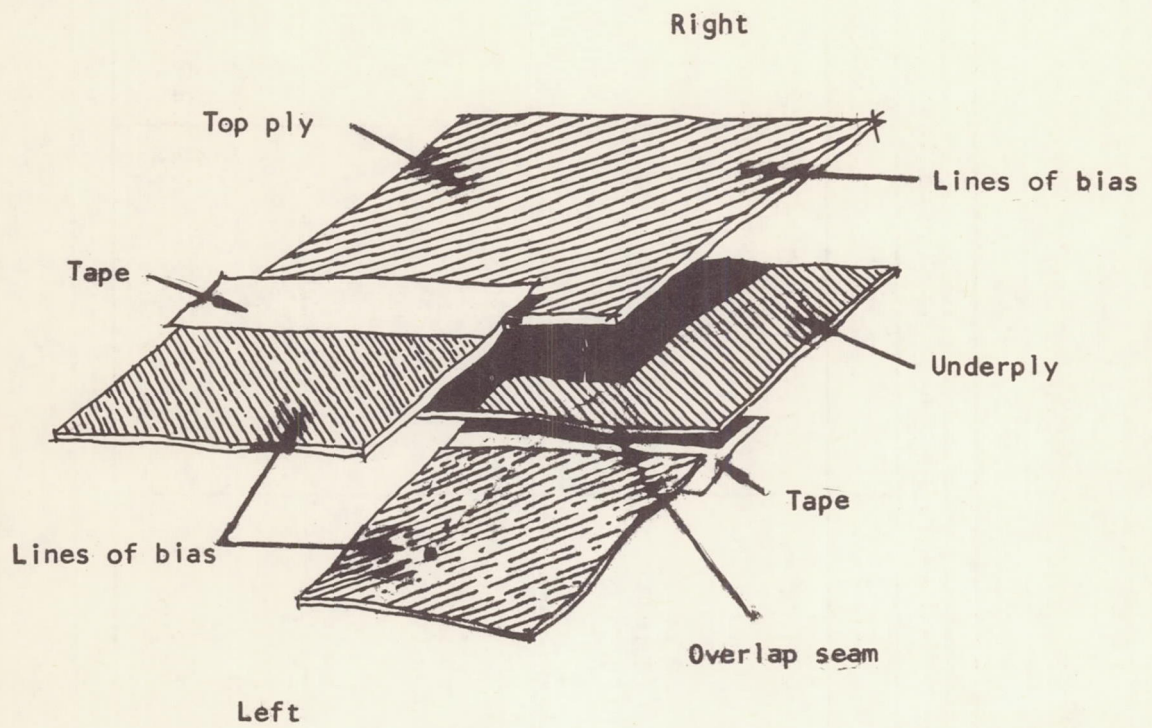


Figure 1.- Method of biasing fabrics so that innate twisting caused by fabric bias is eliminated.

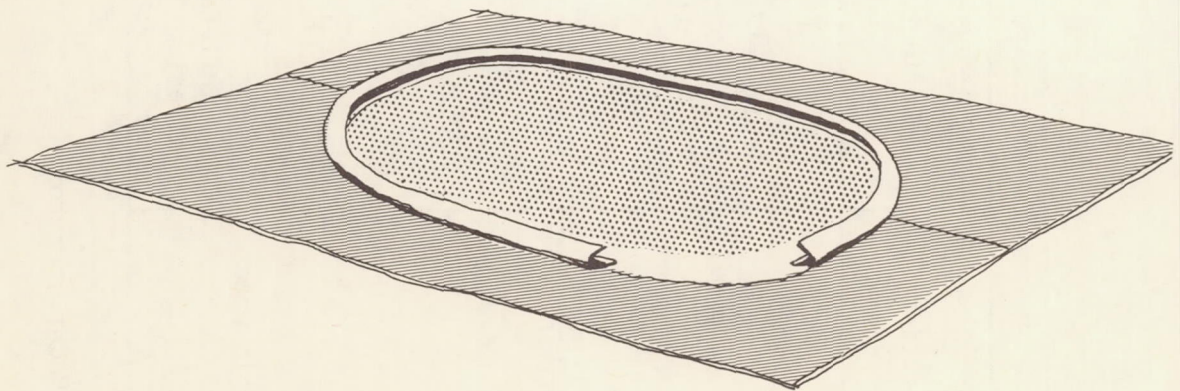


Figure 2.- Tape cementing technique.

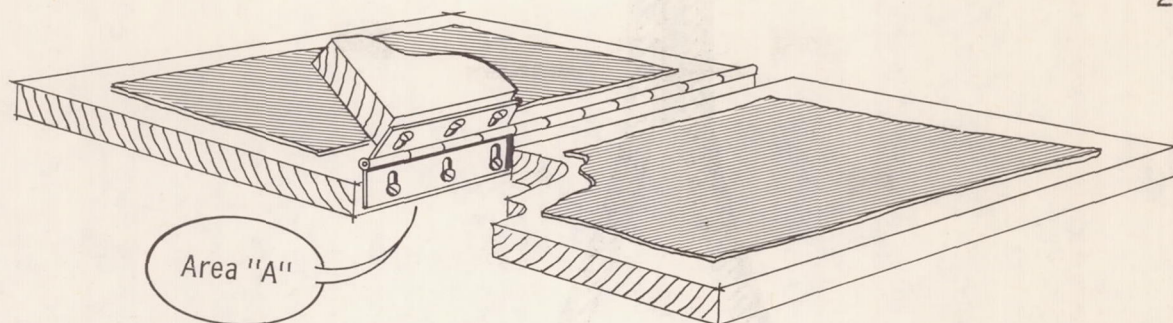


Figure 3.- Hinged jig.

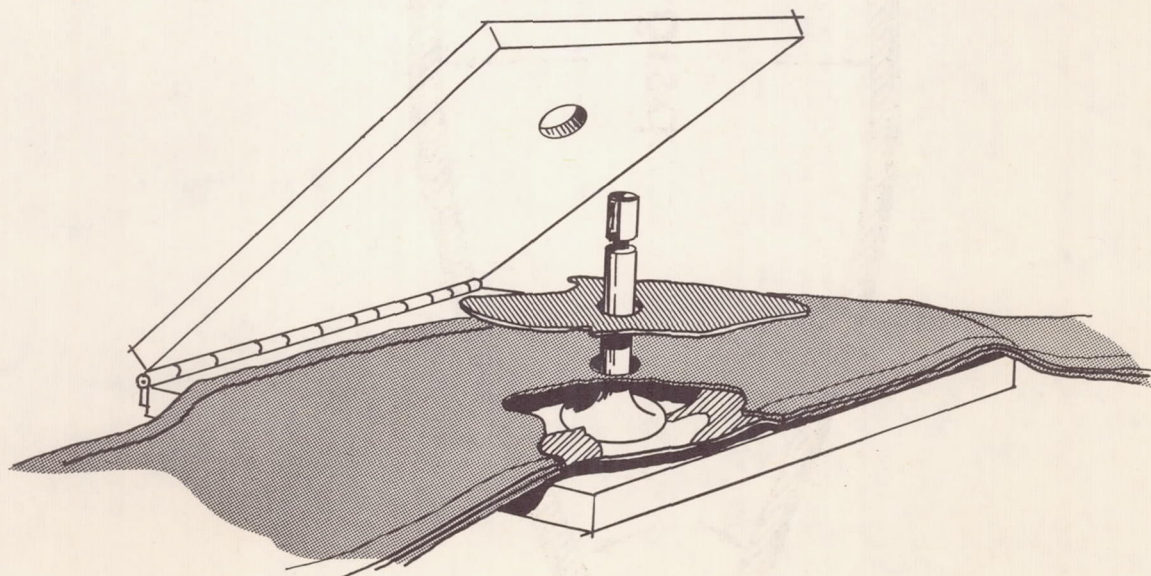


Figure 4.- Hole cut in wooden jig base to allow the fabric to lie flat and to prevent distortion by the oral inflation tube assembly.



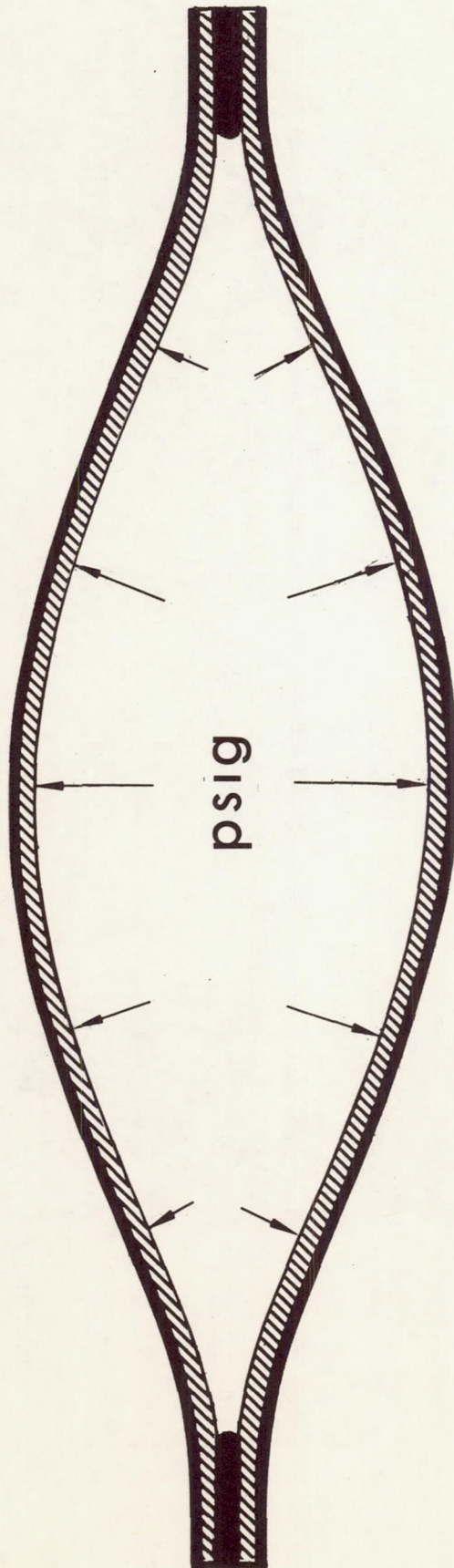


Figure 5.- Cross-sectional sketch showing method of seam joining.

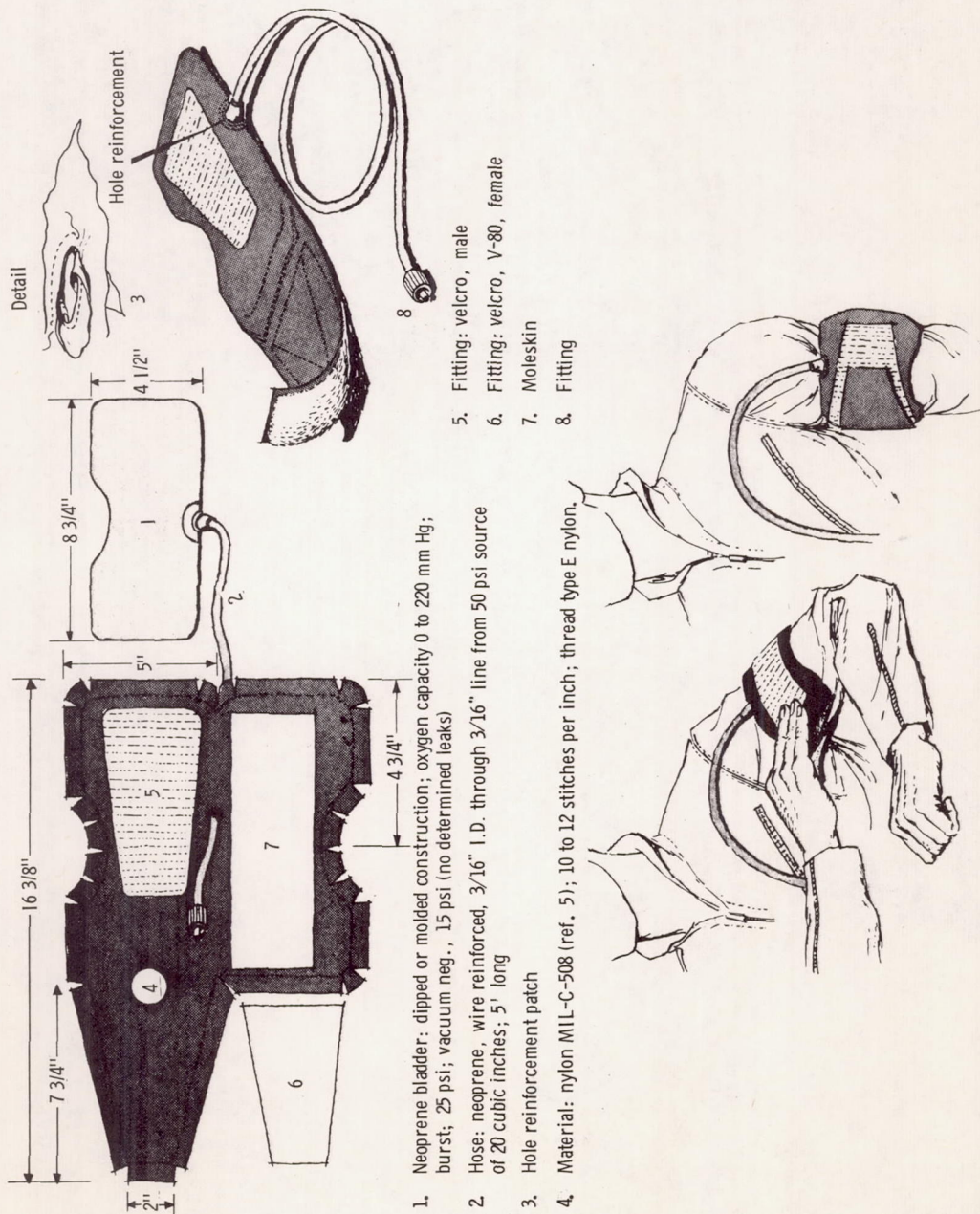


Figure 6.- Blood-pressure cuff. (All cut edges are treated to preclude raveling.)



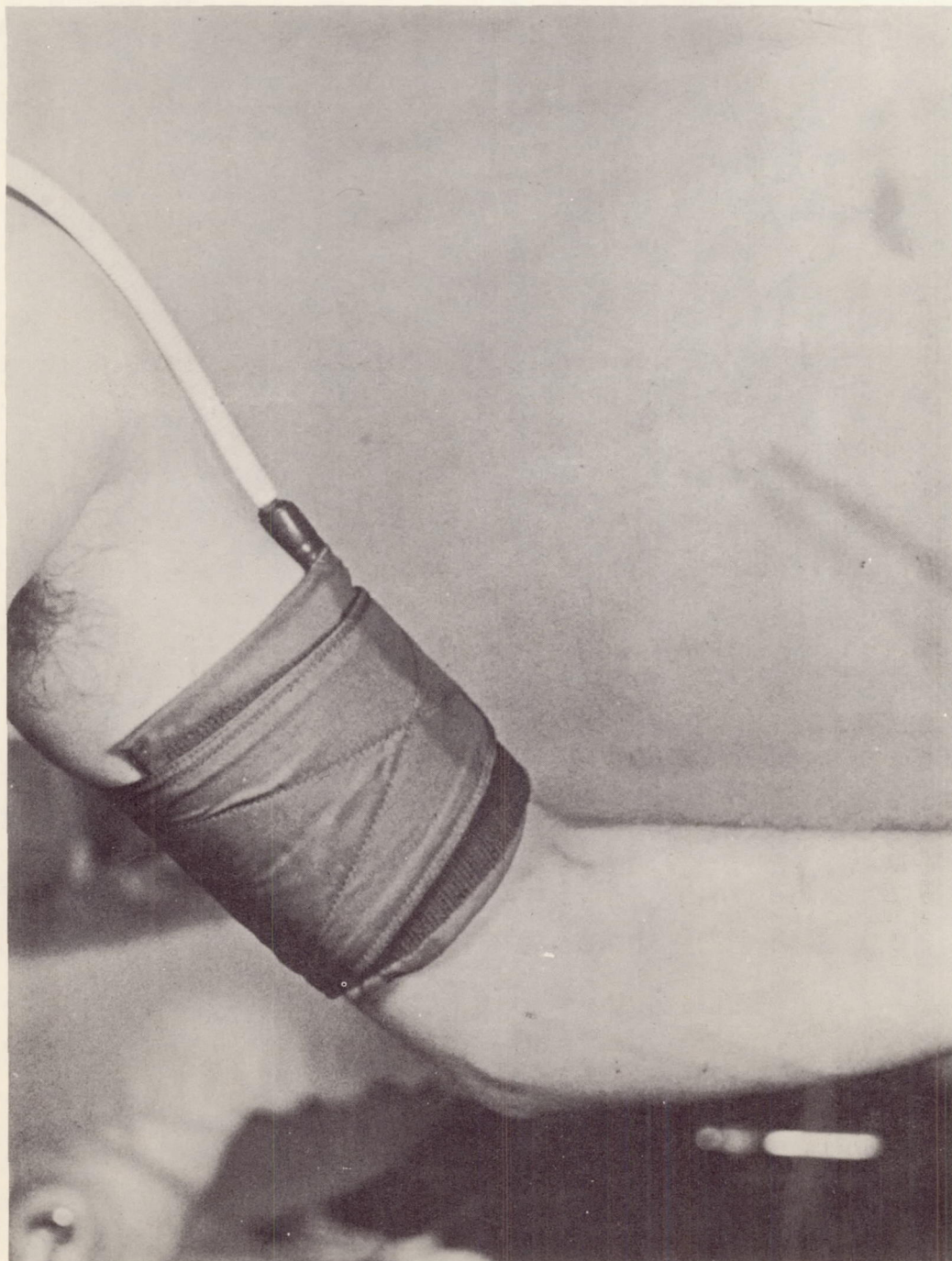


Figure 7.- Photograph of blood-pressure cuff.

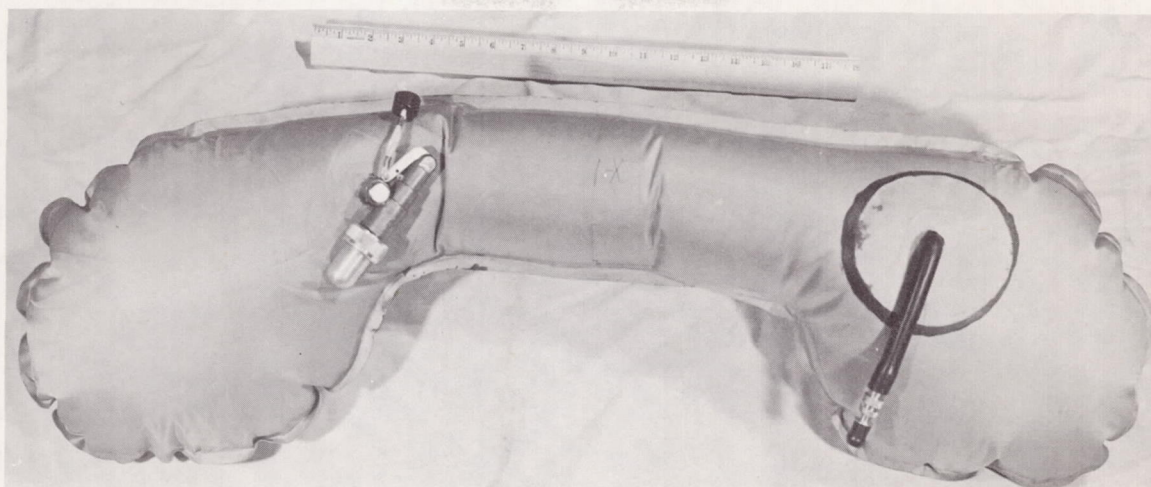


Figure 8.- Lifevest (simple tube configuration).

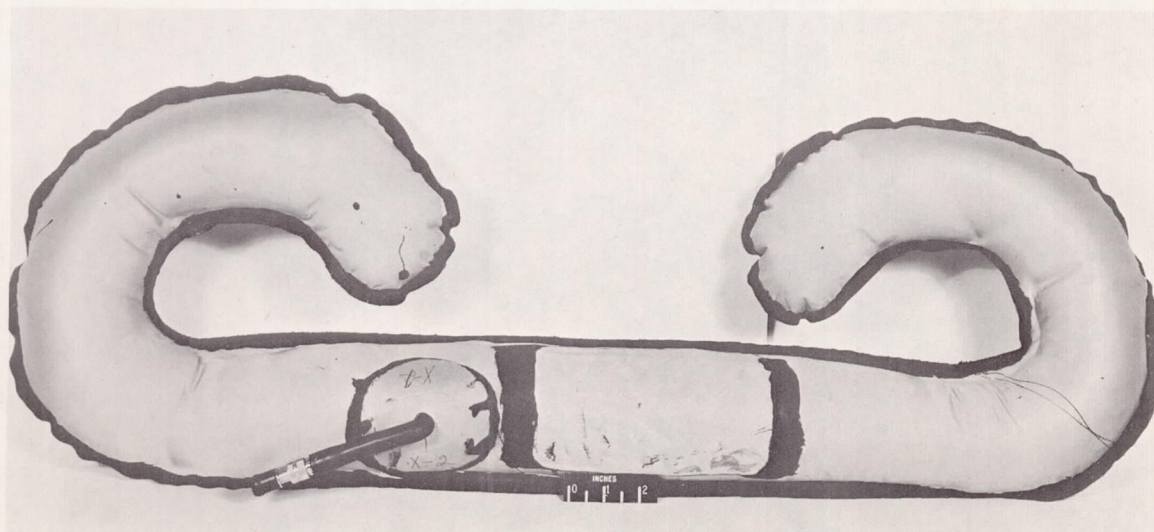


Figure 9.- Lifevest with inflated hooks.



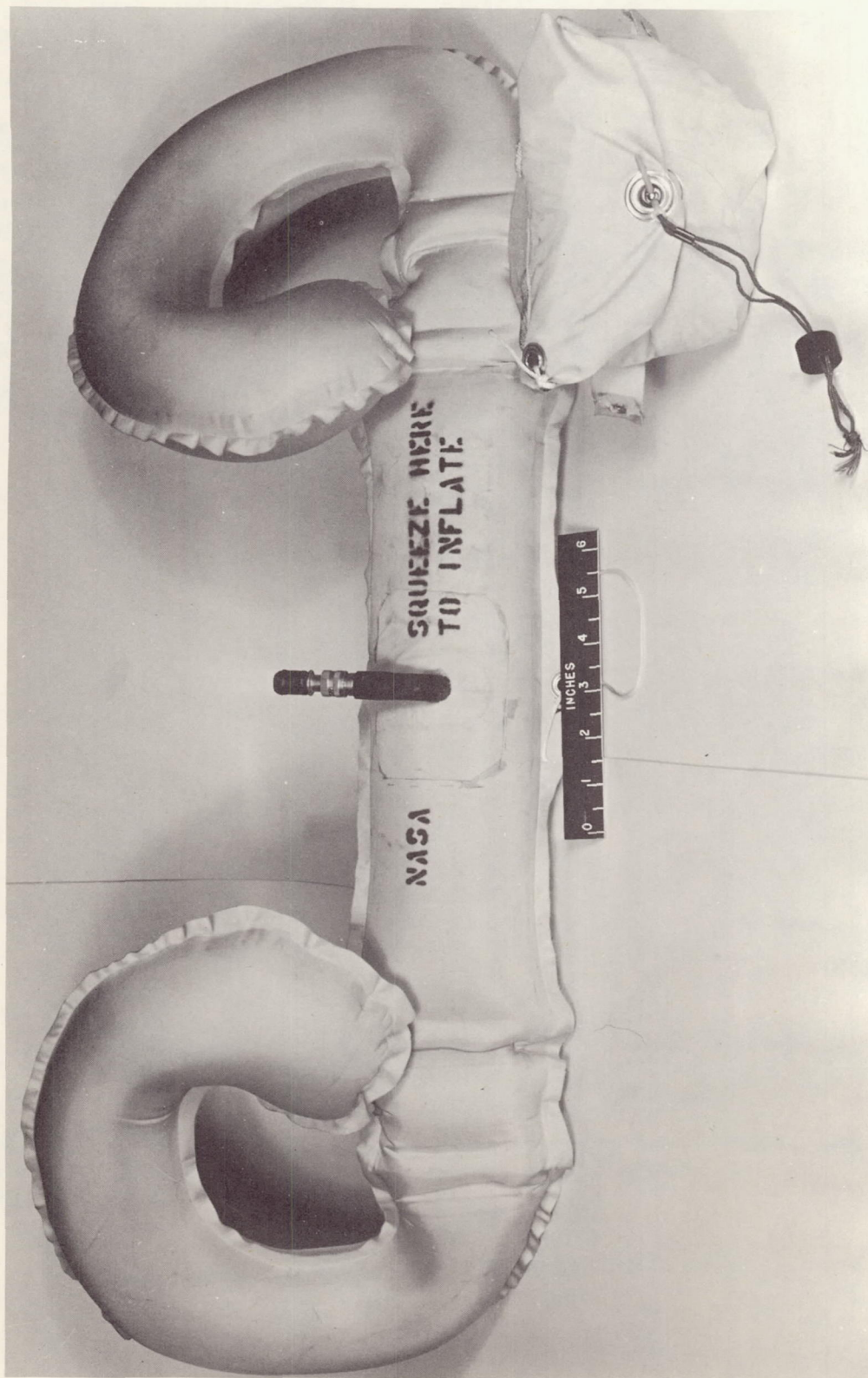


Figure 10.- Lifevest and container.

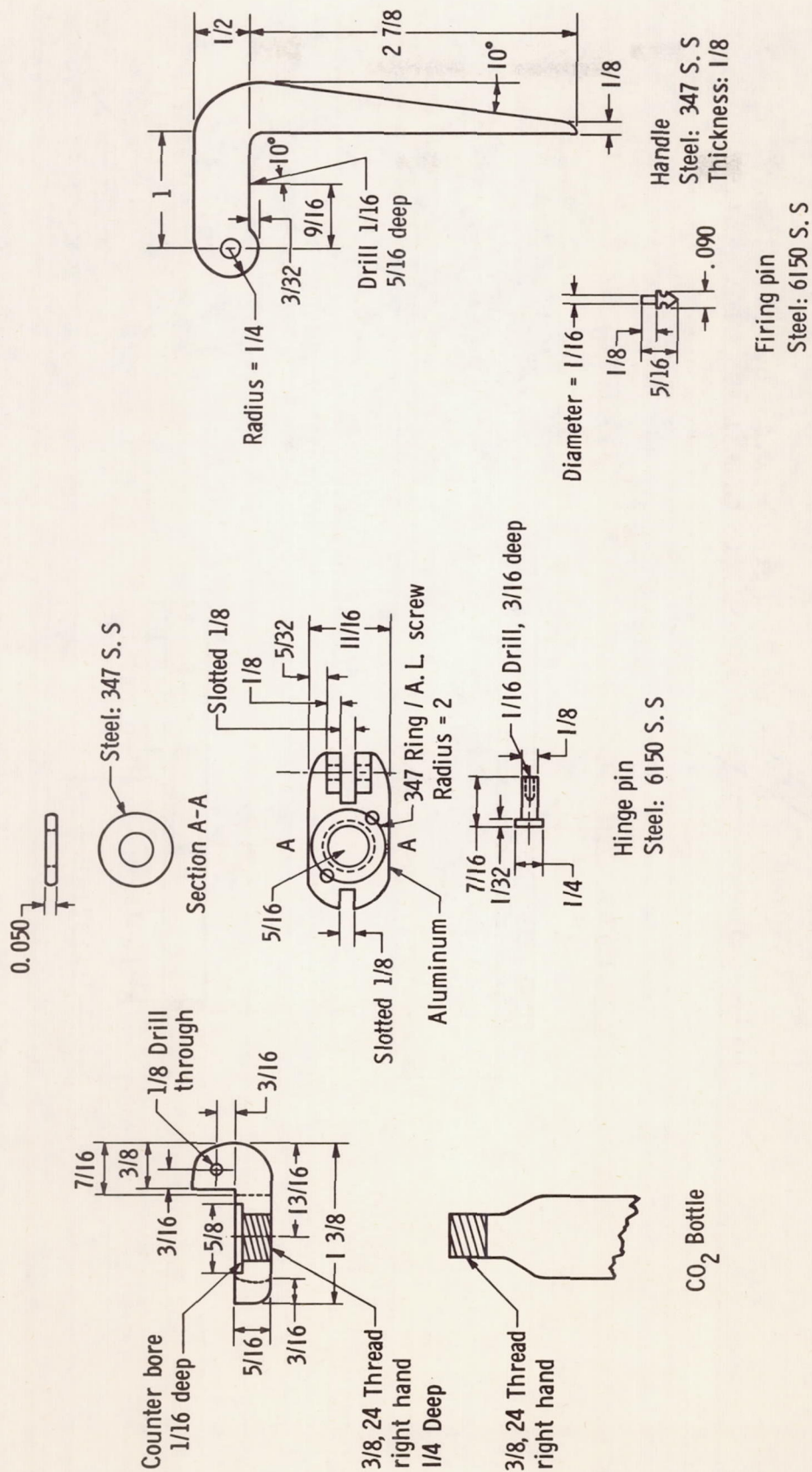


Figure 11.- Diagram of CO<sub>2</sub> trigger mechanism. (All dimensions are in inches.)



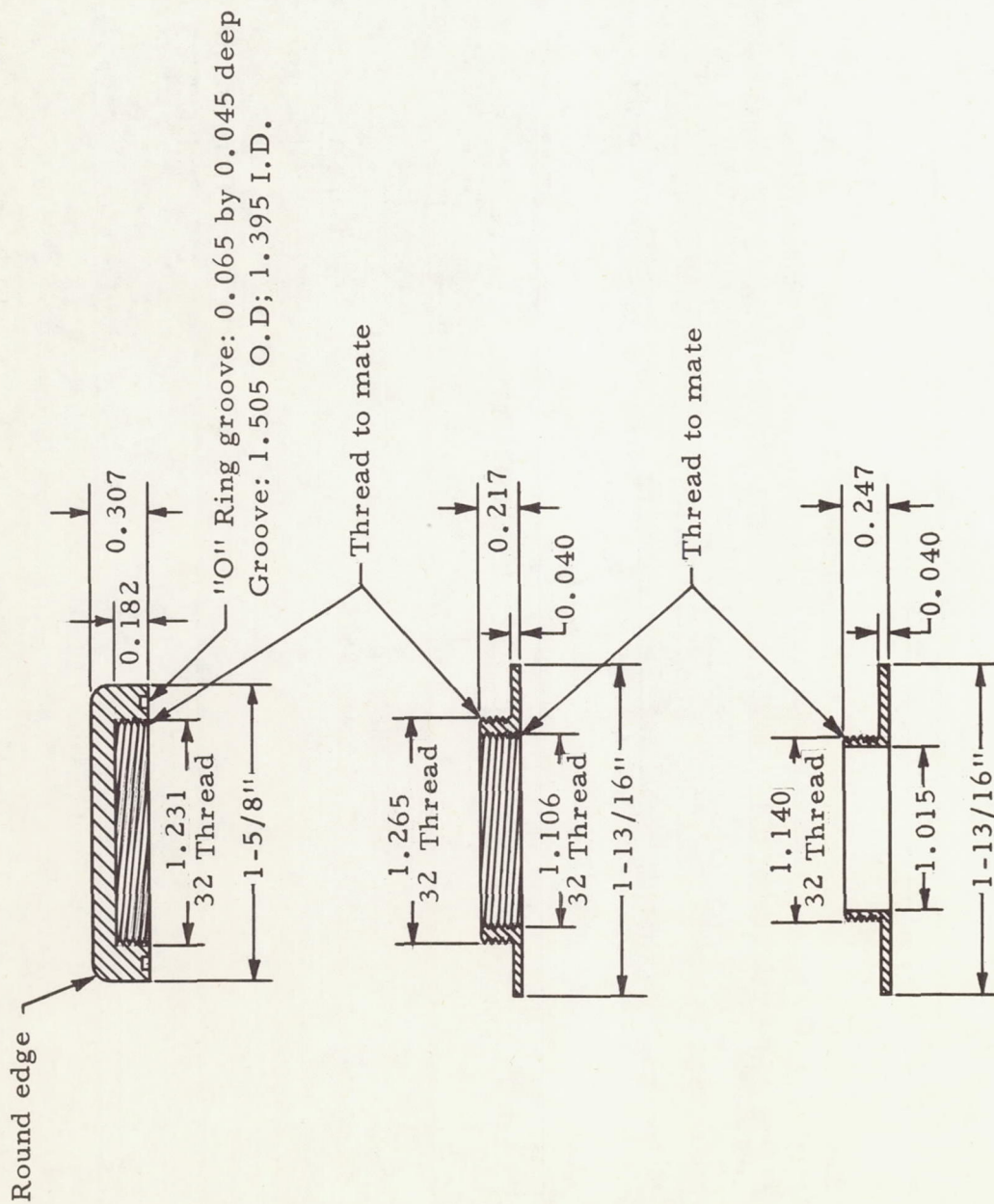


Figure 12.- Diagram showing CO<sub>2</sub> bottle entrance hole fitting. (All dimensions are in inches unless otherwise noted.)

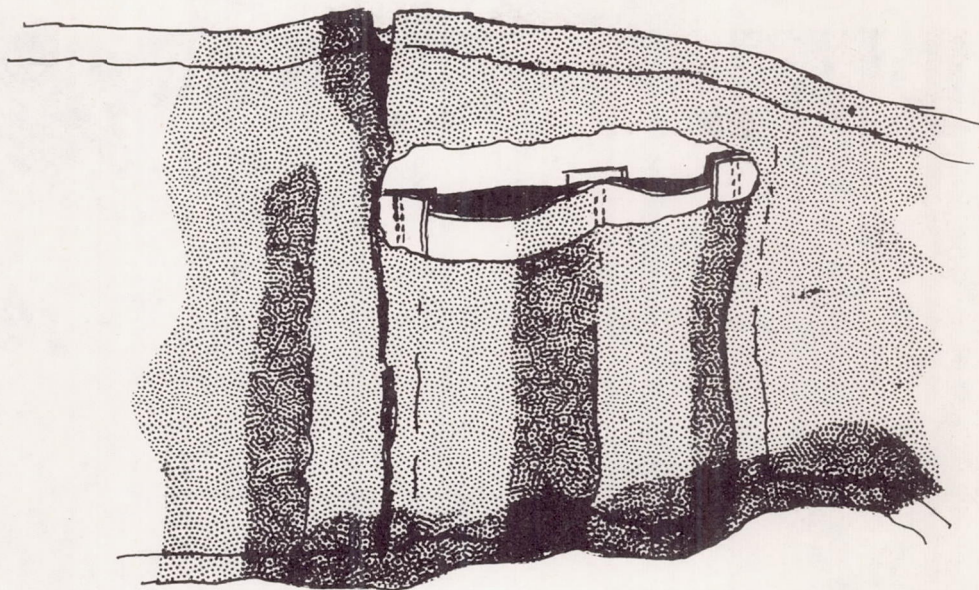


Figure 13.- Sketch showing construction of "V" restraints.

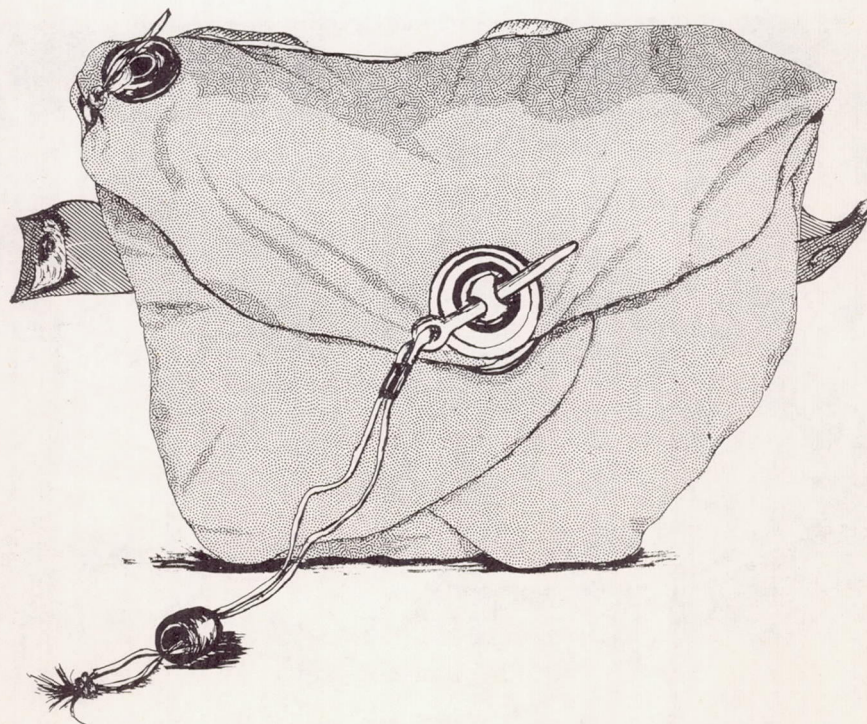
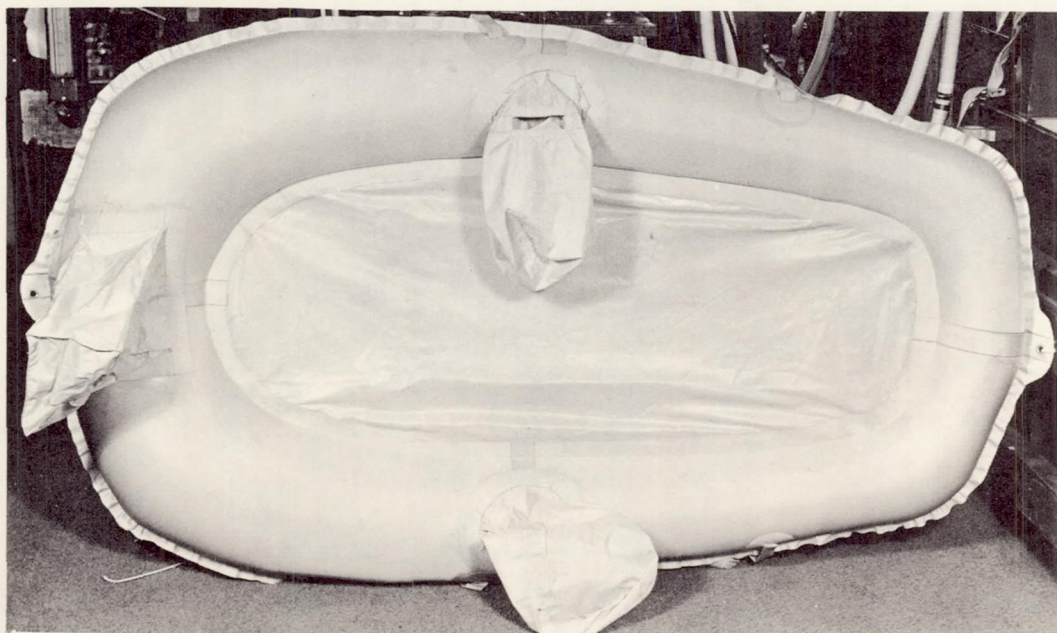


Figure 14.- Trapezoidal packet configuration.





(a) Top view.



(b) Bottom view.

Figure 15.- Photographs of liferaft.



Figure 16.- Liferaft packed for MA-6 spacecraft.



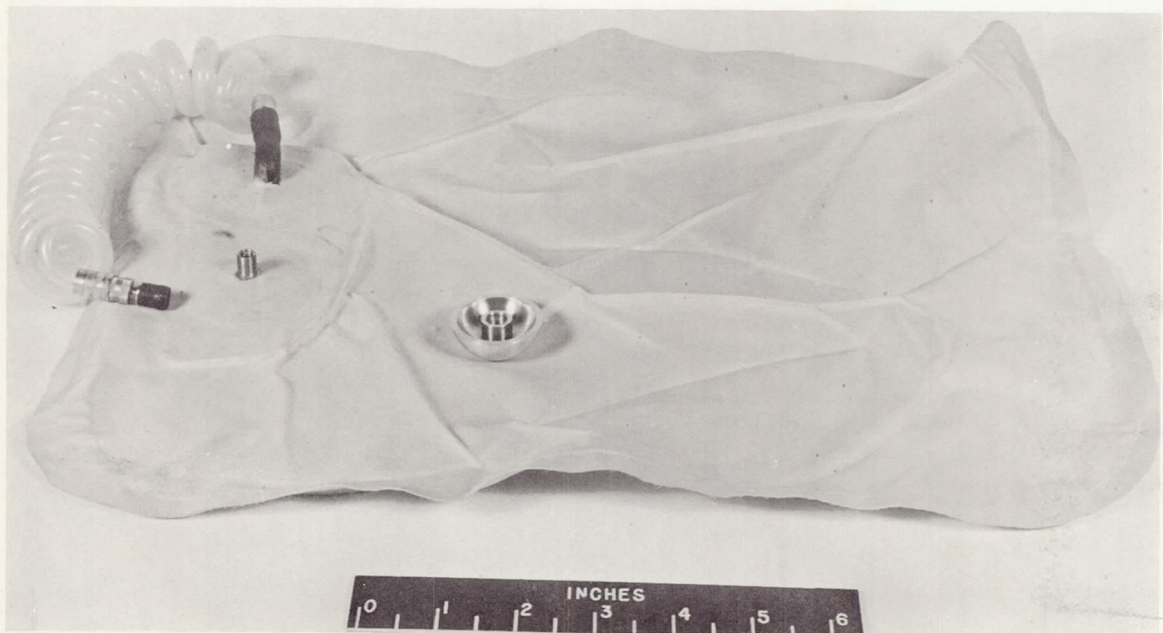


Figure 17.- Water container.

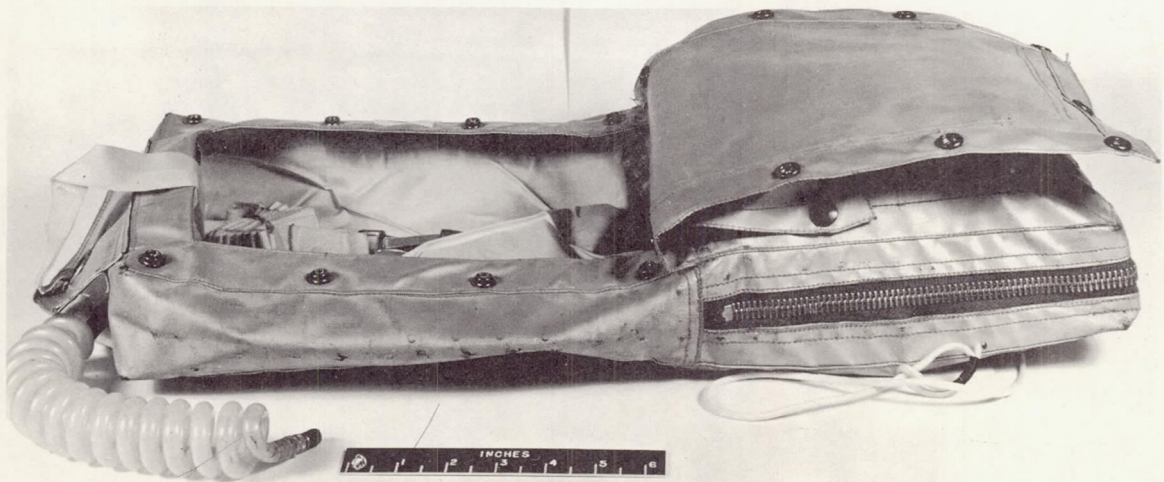


Figure 18.- Water container packed for MA-6 spacecraft.

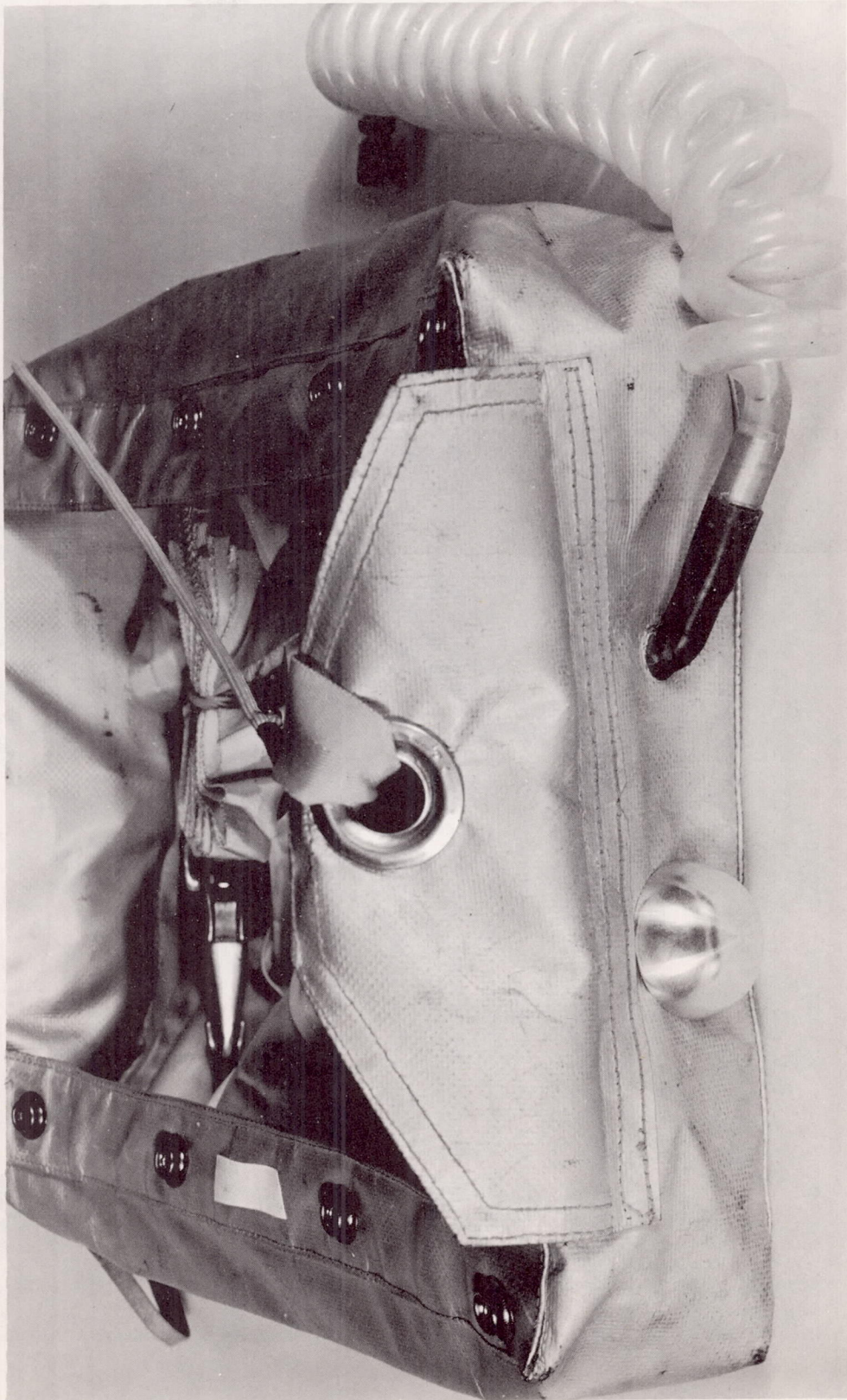


Figure 19.- Water container drinking tube.



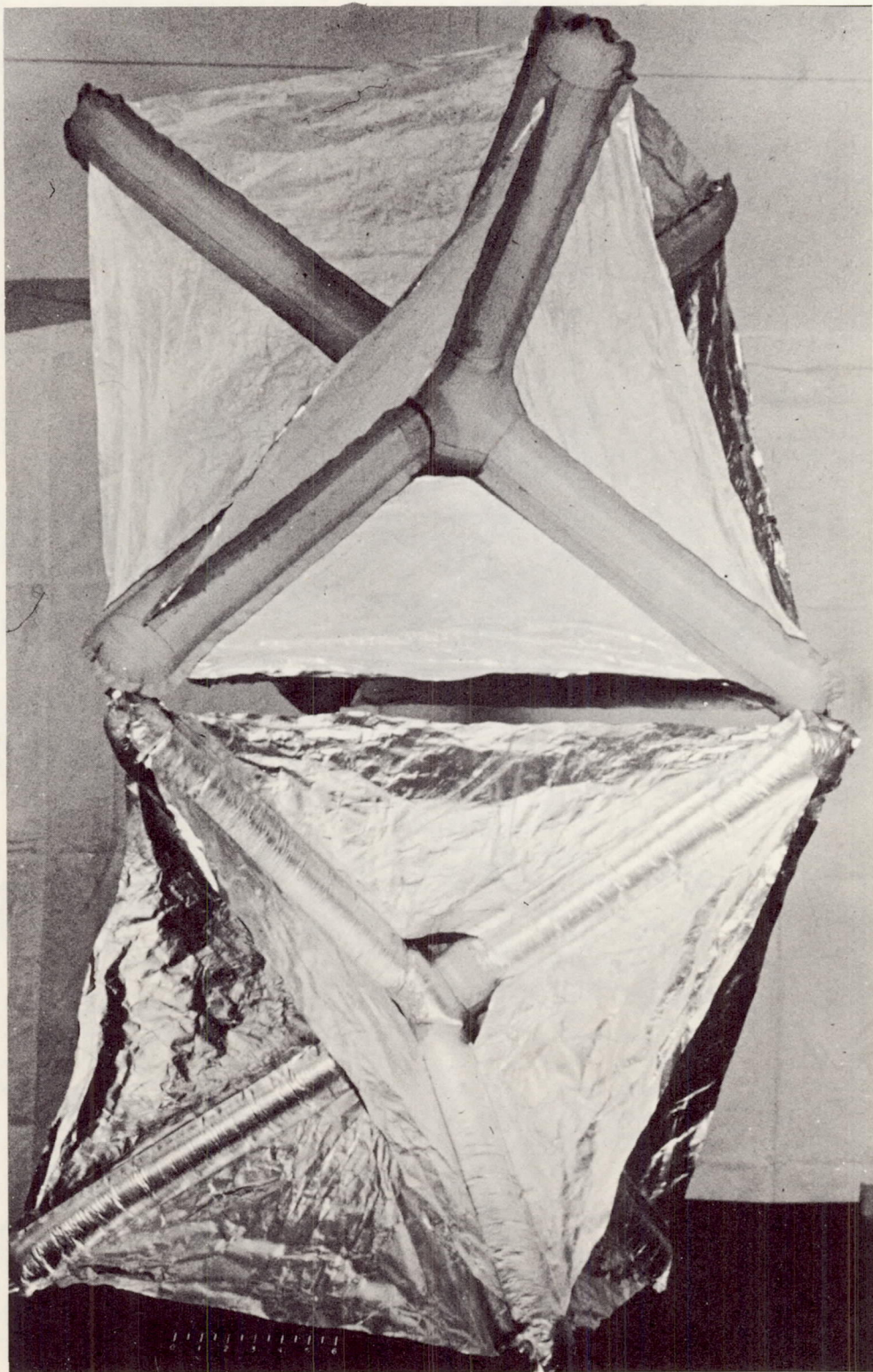


Figure 20.- MSC radar reflector no. 2 (top) radar reflector no. 1  
(bottom).



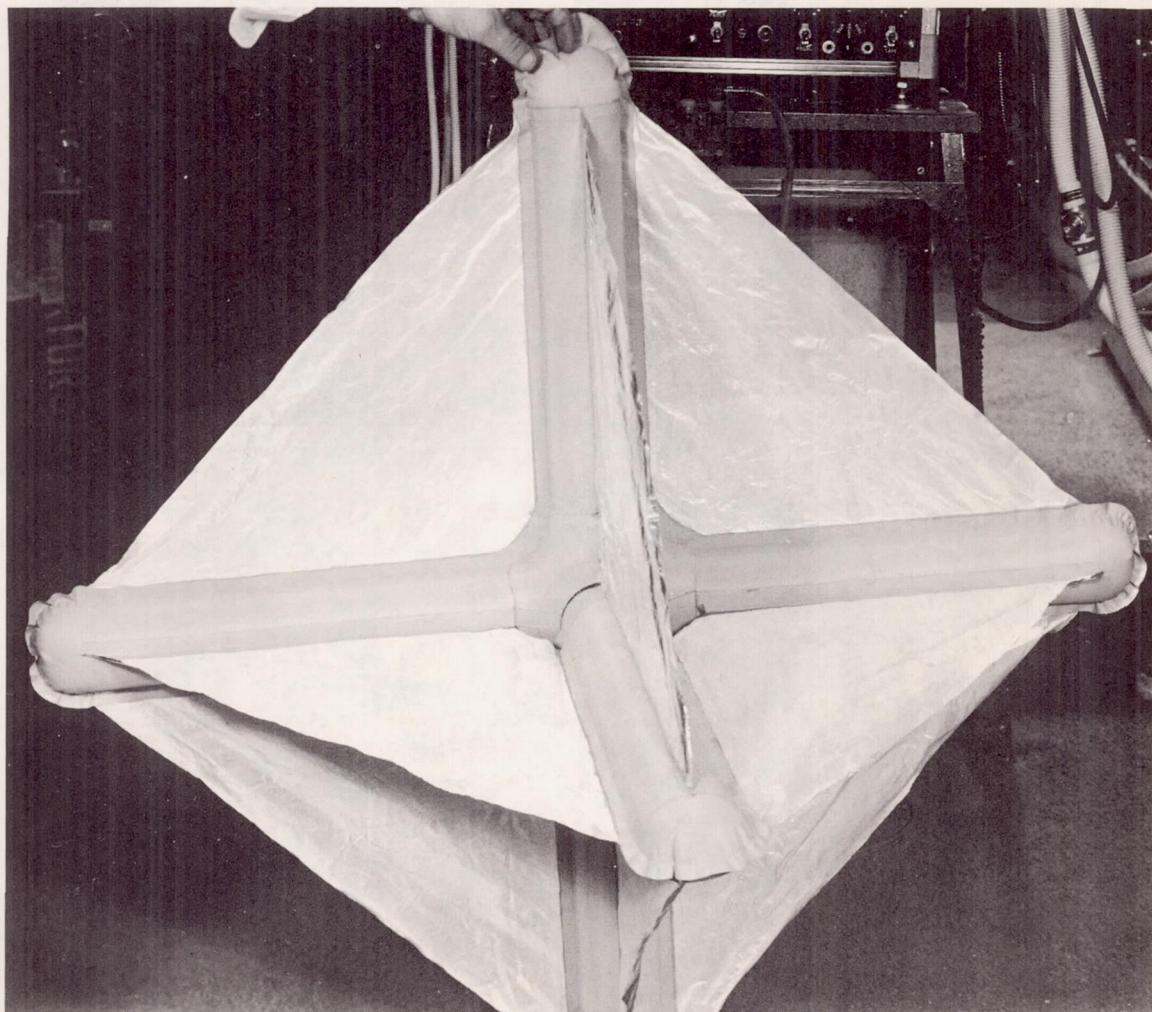


Figure 21.- MSC inflatable radar reflector no. 2 with uncovered nylon tubes.



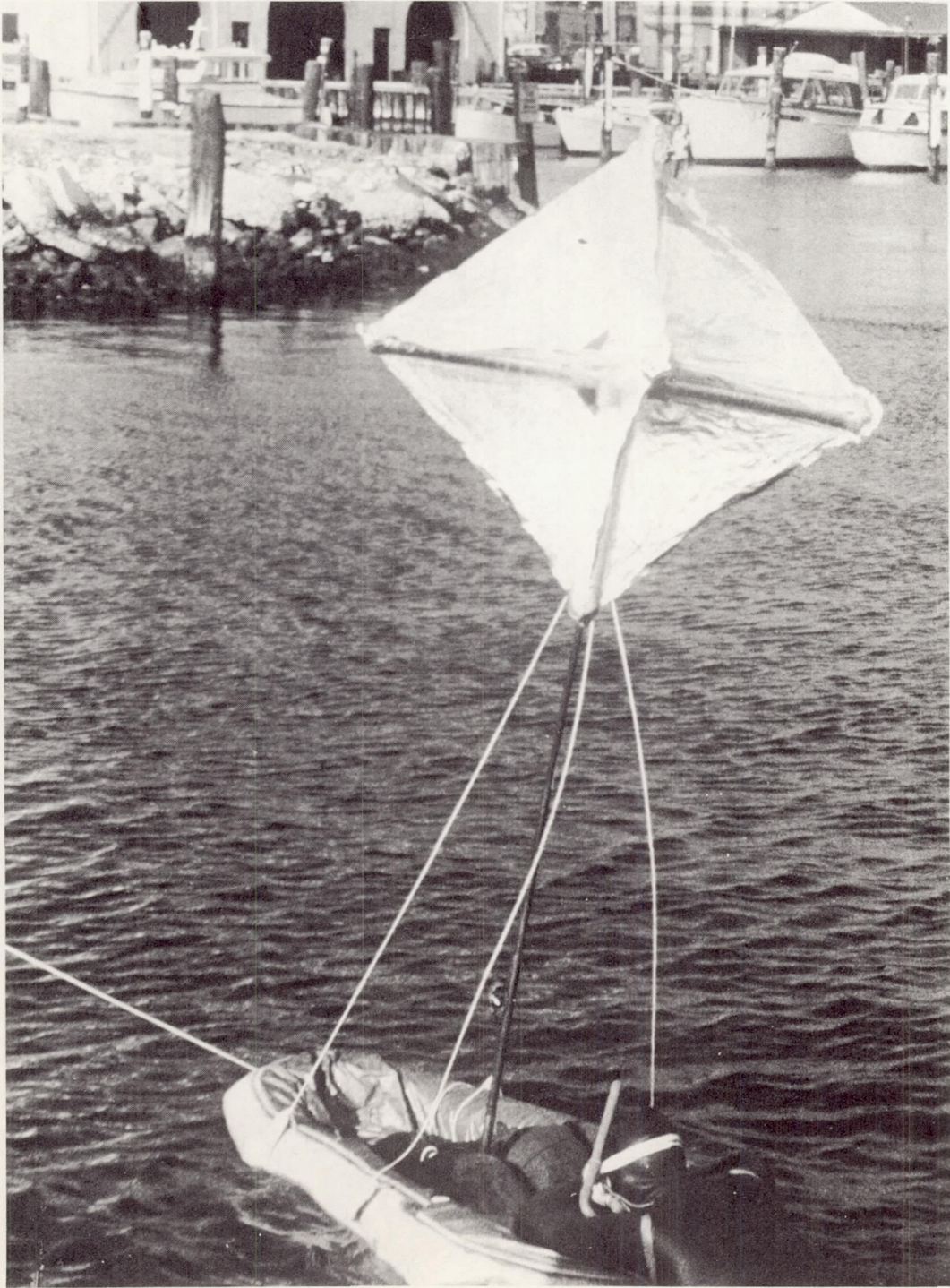


Figure 22.- MSC radar reflector no. 1 attached to the PK-2 rubber life-raft.